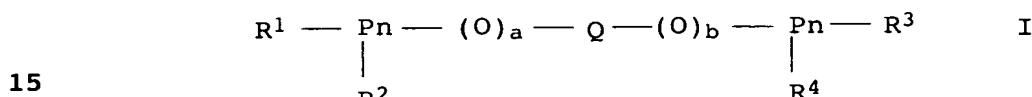


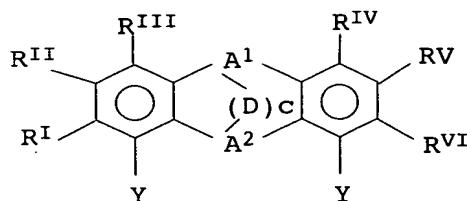
We claim:

1. A process for preparing dialdehydes and/or ethylenically
 5 unsaturated monoaldehydes by reacting at least one compound
 having at least two ethylenically unsaturated double bonds
 with carbon monoxide and hydrogen in the presence of a
 hydroformylation catalyst comprising at least one complex of
 10 a metal of transition group VIII with at least one ligand
 selected from among chelating pnicogen compounds of the
 formula I,



where

Q is a bridging group of the formula



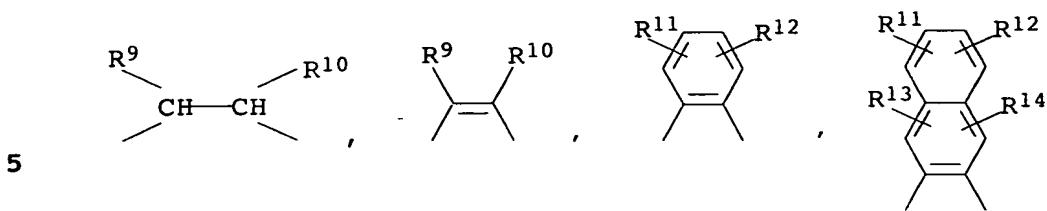
where

A¹ and A² are each, independently of one another, O, S,
 30 SiR^aR^b, NR^c or CR^dR^e, where

R^a, R^b and R^c are each, independently of one another, hydrogen,
 alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl,

35 R^d and R^e are each, independently of one another, hydrogen,
 alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl or
 the group R^d together with a further group R^d or the
 group R^e together with a further group R^e form an
 intramolecular bridging group D,

40 D is a divalent bridging group selected from among the
 groups



where

10 R⁹ and R¹⁰ are each, independently of one another, hydrogen, alkyl, cycloalkyl, aryl, halogen, trifluoromethyl, carboxyl, carboxylate or cyano or are joined to one another to form a C₃-C₄-alkylene bridge,

15 R¹¹, R¹², R¹³ and R¹⁴ are each, independently of one another, hydrogen, alkyl, cycloalkyl, aryl, halogen, trifluoromethyl, COOH, carboxylate, cyano, alkoxy, SO₃H, sulfonate, NE¹E², alkylene-NE¹E²E³X⁻, acyl or nitro,

20 c 0 or 1,

Y is a chemical bond,

25 R^I, R^{II}, R^{III}, R^{IV}, R^V and R^{VI} are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl, hetaryl, COOR^f, COO⁻M⁺, SO₃R^f, SO⁻₃M⁺, NE¹E², NE¹E²E³X⁻, alkylene-NE¹E²E³X⁻, OR^f, SR^f, (CH₂R^gCH₂O)_xR^f, (CH₂N(E¹))_xR^f, (CH₂CH₂N(E¹))_xR^f, halogen, trifluoromethyl, nitro, acyl or cyano,

30 where

35 R^f, E¹, E² and E³ are identical or different radicals selected from among hydrogen, alkyl, cycloalkyl and aryl,

R^g is hydrogen, methyl or ethyl,

M⁺ is a cation,

40 X⁻ is an anion, and

45 x is an integer from 1 to 120,

or

two adjacent radicals selected from among R^I, R^{II}, R^{III}, R^{IV}, R^V and R^{VI} together with two adjacent carbon atoms of the benzene ring to which they are bound for a fused ring system having 1, 2 or 3 further rings,

5

a and b are each, independently of one another, 0 or 1,

Pn is a pnicogen atom selected from among the elements phosphorus, arsenic and antimony,

10

and

R¹, R², R³, R⁴ are each, independently of one another, hetaryl, hetaryloxy, alkyl, alkoxy, aryl, aryloxy, cycloalkyl, cycloalkoxy, heterocycloalkyl, heterocycloalkoxy or an NE¹E² group, with the proviso that R¹ and R³ are pyrrole groups bound via the nitrogen atom to the pnicogen atom Pn

20

or R¹ together with R² and/or R³ together with R⁴ form a divalent group E of the formula

Py-I-W

25

where

Py is a pyrrole group which is bound via the pyrrole nitrogen atom to the pnicogen atom Pn,

30

I is a chemical bond or O, S, SiR^aR^b, NR^c, substituted or unsubstituted C₁-C₁₀-alkylene or CR^hRⁱ,

W is cycloalkyl, cycloalkoxy, aryl, aryloxy, hetaryl or hetaryloxy,

35

and

R^h and Rⁱ are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or hetaryl,

40

or R¹ together with R² and/or R³ together with R⁴ form a bispyrrole group of the formula

45

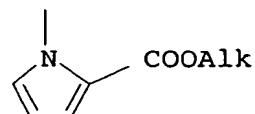
Py-I-Py

bound via the nitrogen atoms to the pnicogen atom Pn.

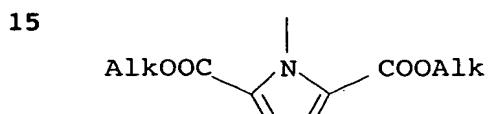
2. A process as claimed in claim 1, wherein at least one ligand of the formula I, in which the radicals R¹, R², R³ and R⁴ are selected independently from among groups of the formulae I.a to I.k



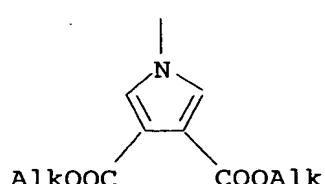
(I.a)



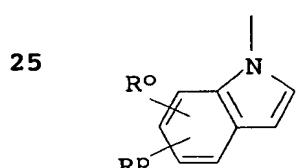
(I.b)



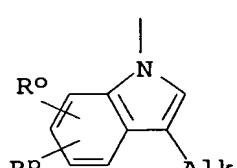
(I.c)



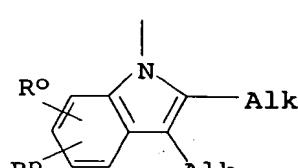
(I.d)



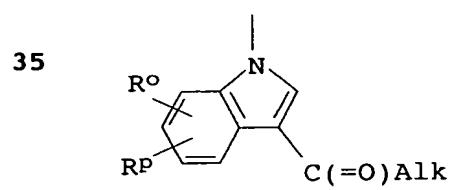
(I.e)



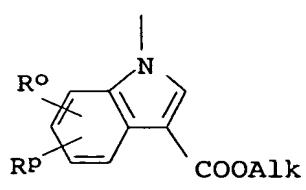
(I.f)



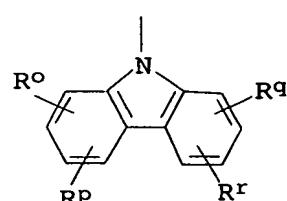
(I.g)



(I.h)



(I.i)



(I.k)

where

45 Alk is a C₁-C₄-alkyl group and

R^o , R^p , R^q and R^r are each, independently of one another, hydrogen, C₁-C₄-alkyl, C₁-C₄-alkoxy, acyl, halogen, trifluoromethyl, C₁-C₄-alkoxycarbonyl or carboxyl, is used.

5

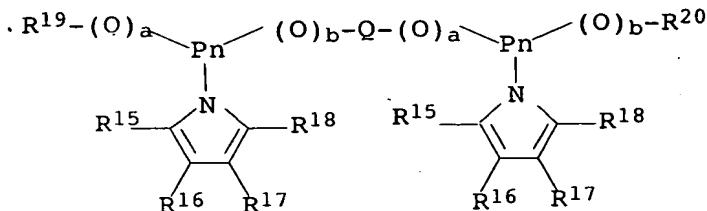
3. A process as claimed in claim 2, wherein at least one ligand of the formula I, in which the radicals R¹, R², R³ and R⁴ are each, independently of one another, a 3-alkylindolyl group, preferably a 3-methylindolyl group, is used.

10

4. A process as claimed in any of the preceding claims, wherein the chelating pnicogen compound of the formula I is selected from among chelating pnicogen compounds of the formula II,

15

20



(II)

25

where

R^{15} , R^{16} , R^{17} and R^{18} are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl, hetaryl, W'COOR^k, W'COO⁻M⁺, W'(SO₃)R^k, W'(SO₃)⁻M⁺, W'PO₃(R^k)(R^l), W'(PO₃)²⁻(M⁺)₂, W'NE⁴E⁵, W'(NE⁴E⁵E⁶)⁺X⁻, W'OR^k, W'SR^k, (CH₂R^lCH₂O)_yR^k, (CH₂NE⁴)_yR^k, (CH₂CH₂NE⁴)_yR^k, halogen, trifluoromethyl, nitro, acyl or cyano,

30

where

35

W' is a single bond, a heteroatom or a divalent bridging group having from 1 to 20 bridge atoms,

40

R^k, E⁴, E⁵, E⁶ are identical or different radicals selected from among hydrogen, alkyl, cycloalkyl and aryl,

R^l is hydrogen, methyl or ethyl,

M⁺ is a cation equivalent,

45

X⁻ is an anion equivalent and

y is an integer from 1 to 240,

where two adjacent radicals R¹⁵, R¹⁶, R¹⁷ and R¹⁸ together with
the carbon atoms of the pyrrole ring to which they are bound
5 may also form a fused ring system having 1, 2 or 3 further
rings,

with the proviso that at least one of the radicals R¹⁵, R¹⁶,
R¹⁷ and R¹⁸ is not hydrogen and R¹⁹ and R²⁰ are not joined to
10 one another,

R¹⁹ and R²⁰ are each, independently of one another,
15 cycloalkyl, heterocycloalkyl, aryl or hetaryl, or R¹⁹
together with R¹⁵ or R¹⁶ and/or R¹⁹ together with R¹⁷ or
R¹⁸ form a divalent group

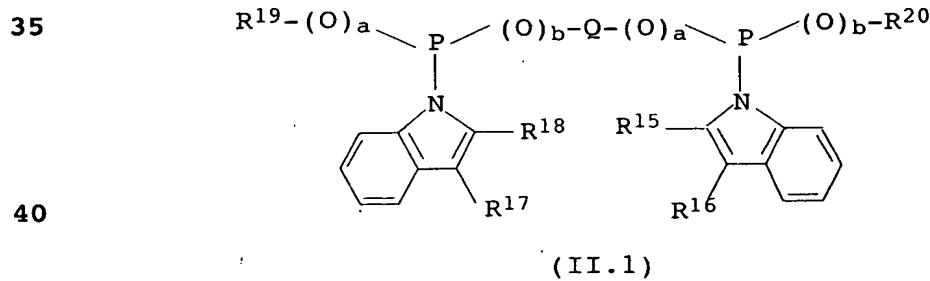
-I-W-

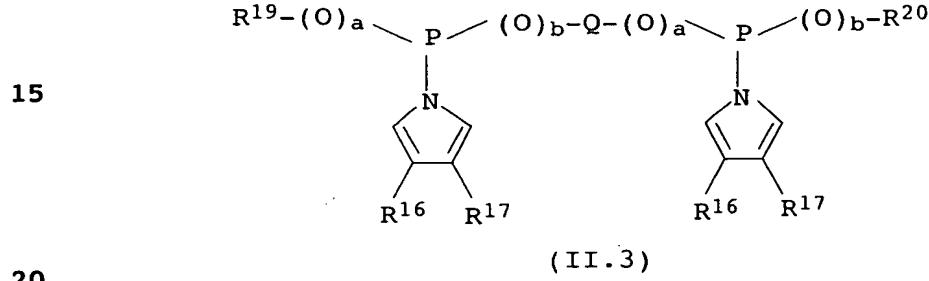
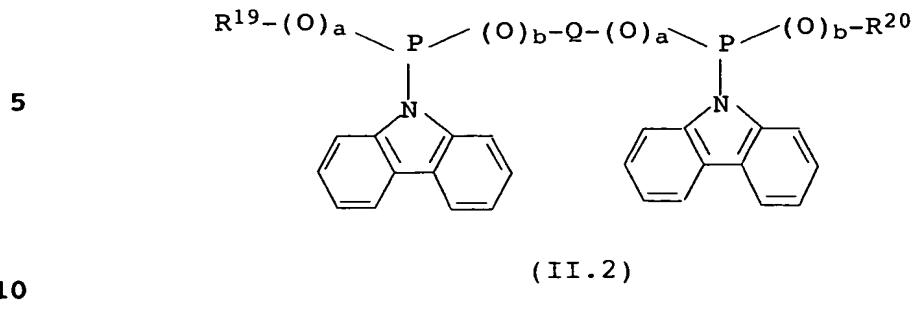
where

I is a chemical bond or O, S, SiR^aR^b, NR^c or substituted or
20 unsubstituted C₁-C₁₀-alkylene, preferably CR^hRⁱ, where R^a,
R^b, R^c, R^h and Rⁱ are each, independently of one another,
hydrogen, alkyl, cycloalkyl, heterocycloalkyl, aryl or
hetaryl and

25 W is cycloalkyl, cycloalkoxy, aryl, aryloxy, hetaryl or
hetaryloxy.

5. A process as claimed in any of the preceding claims, wherein
30 the chelating pnicogen compound of the formula I is a
chelating pnicogen compound of the formulae II.1 to II.3,



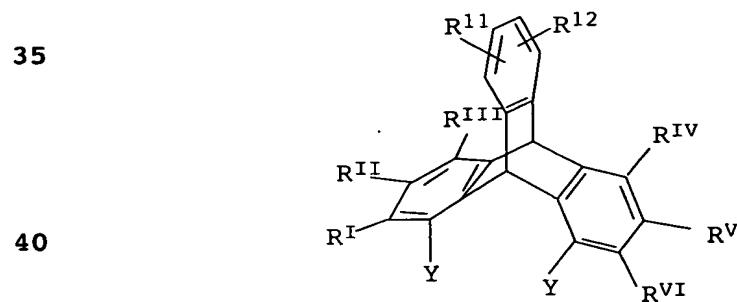


where

25 R¹⁵, R¹⁶, R¹⁷, R¹⁸, Q, a and b are as defined in claim 4, where
at least one of the radicals R¹⁶ and R¹⁷ in the formula
II.3 is not hydrogen,

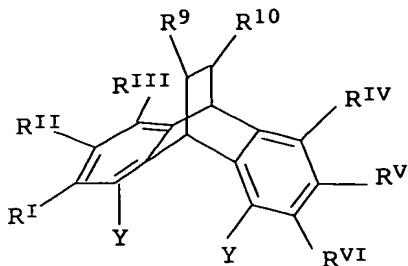
R^{19} and R^{20} are each, independently of one another, cycloalkyl, heterocycloalkyl, aryl or hetaryl.

30 6. A process as claimed in any of claims 1 to 5, wherein the bridging group Q is a triptycenediyl group of the formula



or the formula

5

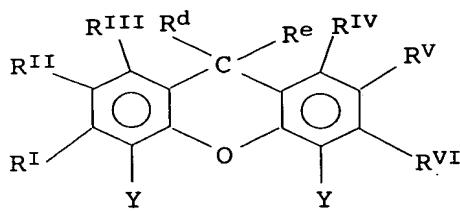


10 where RI, RII, RIII, RIV, RV and RVI, R9, R10, R11 and R12 are as defined in claim 1.

7. A process as claimed in any of claims 1 to 5, wherein the bridging group Q is a xanthenediyl group of the formula

15

20



25 where RI, RII, RIII, RIV, RV and RVI and Y are as defined in claim 1 and Rd and Re are each, independently of one another, hydrogen, alkyl, cycloalkyl, heterocyloalkyl, aryl or hetaryl.

30 8. A process as claimed in any of the preceding claims, wherein a molar ratio of ligand to metal of transition group VIII of from 1:1 to 1000:1 is set in the reaction mixture.

35 9. A process as claimed in any of the preceding claims, wherein the reaction is carried out at from 40 to 80°C.

10. A process as claimed in any of the preceding claims, wherein the compound having at least two ethylenically unsaturated double bonds which is used is a α,ω-diolefin.

40 11. A process as claimed in any of the preceding claims, wherein

(i) a compound having at least two ethylenically unsaturated double bonds is subjected to the hydroformylation reaction in a reaction zone,

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(ii) an output is taken from the reaction zone and is fractionated to give a fraction enriched in unsaturated monoaldehydes and a fraction depleted in unsaturated monoaldehydes, and

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(iii) the fraction depleted in unsaturated monoaldehydes is recirculated, if appropriate after work-up, to the reaction zone.

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